SECTION 5—ELECTRONICS TECHNOLOGY

OVERVIEW

The array of technologies covered in Section 5.0 is related to Microelectronics (General Purpose Integrated Circuits), Opto-Electronics, Electronic Components, General Purpose Equipment, Fabrication Equipment, and Materials. Militarily critical technologies include materials and techniques that enable the extreme density and high performance, with low power, of Very Large Scale Integrated Circuits (VLSI), Ultra Large Scale Integrated Circuits (ULSI), and Very High-Speed Integrated Circuits (VHSIC). These technologies also include microwave/millimeter wave tubes, integrated circuits and devices, manufacturing equipment, and materials. Computer aided design, manufacturing and test (CAD/CAM/CAT) capabilities to turn out practical working systems in a timely and efficient manner are companion capabilities which must keep pace to allow the effective use of these critical technologies. The performance of processors and capacity of memory chips has doubled every 18 months since 1970. Other semiconductor chips have followed this pattern. This exponential growth is expected to continue until 2005. As the count of transistors on a chip continues to grow exponentially, the cost of building a top-of-the-line chip fabrication plant has also risen because of the higher costs associated with the increasingly exotic facilities and tools need to etch finer and finer lines on a chip. By that time, the price per transistor is expected to bottom out. Each new generation of chips will continue to produce a smaller return on investment and there will no longer be an economic incentive for making transistors smaller. The huge investment required for new fabrication plants will result in the realignment of today's chip manufacturers. There are many joint ventures being formed between U.S. and Japanese to share the huge investment required for new fabrication plants. This trend is expected to continue and the end of some of today's chip manufacturers is expected because there won't be a business case for many new multi-billion dollar fabrication plants after 2005.

SECTION 5.1—ELECTRONIC COMPONENTS

OVERVIEW

Arrays of electronic components include technologies to design and build microwave tubes, solid-state microwave/millimeter wave, superconducting electronics and acoustic wave devices. These technologies are being supported by a current Tri-Service Vacuum Electronics Initiative R&D program for microwave tubes and the DoD Electronics Technology Program for solid-state devices. Electronic devices are vital components in most military systems. Their use includes computers, missiles, avionics, electronic attack (EA), early warning radars, guided munitions, and satellites. The microwave tube, acoustics, and superconducting technologies are unique enabling technologies in that no alternative technology can be substituted for some power and frequency regimes. At present this is limited dual-use technology and military use is 80 percent of the U.S. consumption.

Table 5.1-1. Electronic Components Militarily Critical Technology Parameters

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
TRAVELING WAVE TUBES, PULSED OR CONTINUOUS WAVE	Operating frequency higher than 46 GHz Having a cathode heater element which has a turn-on time < 3 seconds to rated RF power	Tungsten wire tape, Molybdenum wire tape, APBN Boron Nitride Rods, Cathode Nickel	None identified	CAD of gun, collector and circuit	WA IL Cat 3 WA ML 11 MTCR 11
COUPLED CAVITY TUBES, OR DERIVATIVES THEREOF	An "instantaneous bandwidth" > 10% or a peak power > 50 kW.	70/30 Cupronickel Cathode nickel	None identified	None identified	WA IL Cat 3 WA ML 11 MTCR 11
HELIX TUBES, OR DERIVATIVES THEREOF	"bandwidth" > one octave, and average power times frequency > 2 (kW-GHz); "bandwidth" ≤ one octave, and average power times frequency > 4 (kW-GHz)	Tungsten wire tape, Molybdenum wire tape APBN Boron Nitride Rods Cathode Nickel	None identified	CAD of gun, collector and circuit	WA IL Cat 3 WA ML 11 MTCR 11
CROSS-FIELD AMPLIFIER TUBES	A gain > 17 dB or noise figure < 35 dB	Corning 77 Glass Rhenium tungsten wire	None identified	None identified	WA IL Cat 3 WA ML 11 MTCR 11
IMPREGNATED CATHODES FOR ELECTRONIC TUBES	Having a turn on time to rated emission of less than 3 seconds; or Producing a continuous emission current density at rated operating conditions exceeding 10 A/cm^2	None identified	None identified	CAD of electron gun	WA IL Cat 3 WA ML 11 MTCR 11
MICROWAVE POWER AMPLIFIERS CONTAINING TUBES	Operate above 3 GHz or output power density exceeding 80 W/kg and volume < 400 cubic centimeters	None identified	None identified	CAD of gun, collector and power supply circuit	WA IL Cat 3 WA ML 11 MTCR 11
ACOUSTIC WAVE DEVICES - BULK	Frequency ≥ 1 GHz	None identified	None identified	None identified	WA IL Cat 3 WA ML 11 MTCR 11

(Continued)

Table 5.1-1. Electronic Components Militarily Critical Technology Parameters (Continued)

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
ACOUSTIC WAVE DEVICES - SURFACE WAVE	Frequency > 1 GHz Sidelobe > 55 DB	None identified	Sub-micron photolithographic equipment	Unique CAD tools needed for high performance	WA IL Cat 3 WA ML 11 MTCR 11
MICROWAVE/MILLIMETER WAVE INTEGRATED CIRCUITS (MMIC)	Frequency > 3 GHz	None identified	Automatic on-chip testers; automated fabrication equipment for high-volume production, automatic network analyzer	Unique CAD, CAM, CAE software needed	WA IL Cat 3 WA ML 11 MTCR 11
MICROWAVE/ MILLIMETER WAVE TRANSISTORS	Frequency > 40 GHz	GaAs or other III/V or II/VI materials	Automatic network analyzers, on-chip testers, fabrication equipment, especially for sub-micron geometries and large volume production	Unique software is needed to design devices	WA IL Cat 3 WA ML 11 MTCR 11

SECTION 5.2—ELECTRONIC MATERIALS

OVERVIEW

This technology area includes the preparation and processing of new and current electronic and Opto-Electronic (OE) materials from the purification of the basic elements to the final wafer or substrate material ready for device fabrication. Materials handling and their processes are currently undergoing rapid changes to meet the future demands of the electronic industry. These materials are made of very pure starting materials. Preparation methods are numerous, depending on the material under consideration, liquid state preparation (separation of liquid metals), and the making of gases used in the compounding of crystal-starting materials or in epitaxial growth (hydrides, halides, anometallic compounds, and use of pure elemental gases).

Table 5.2-1. Electronic Materials Militarily Critical Technology Parameters

Technology	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
Hetero-epitaxial materials with epitaxially grown layers of Silicon, Germanium, III/V compounds or II/VI compounds.	Capability to produce hetero-epitaxial materials consisting of a "substrate" with stacked low defect density epitaxially grown multiple layers of Silicon, Germanium, III/V or II/VI compounds to a flatness of ± 3 to 5% across 75 mm or less than ± 50 angstroms across 400 mm	Hetero-epitaxial materials with epitaxially grown layers of Silicon, Germanium, III/V compounds or II/VI compounds. Metal-organic compounds and hydrides used as precursors.	MOCVD (Metal Organic Chemical Vapor Deposition) and MBE (Molecular Beam Epitaxy) epitaxial growth equipment. Bulk and surface lifetimes for ultra-thin film testing	Special algorithms are used to control the growth process of the materials.	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22
Resist Materials	Positive resist optimized for use at wavelengths < 400 nm E-beam or Ion-beam resist with sensitivity of > 0.01 microcoulomb/mm^2 X-ray resist with sensitivity of 2.5 mJ/mm^2 Resist optimized for surface imaging technologies, and silyated resist.	Light sensitive polymers for use at wavelengths < 400 mm, polymers sensitive to exposure by, E-beam, X-ray and ion beam.	Spectroscopic ellipsometer, spectrophotometer. Equipment for: defect detection and classification, viscosymeters; interferometeric measurement equipment.	None identified	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22
Metal Organic Compounds	Metal-organic compounds of aluminum, gallium, indium, arsenic or antimony or organic compounds of phosphorus, having a purity better than 99.999 %.	Metal-organic compounds of aluminum, gallium, indium, arsenic or antimony or organic compounds of phosphorus, having a purity better than 99.999%.	Optical spectroscopy	Special algorithms are used to control the synthesis of the materials.	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22

(Continued)

Table 5.2-1. Electronic Materials Militarily Critical Technology Parameters (Continued)

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
HYDRIDES	Hydrides of phosphorus, arsenic or antimony, having a purity > 99.999%, even diluted in neutral gases.	Hydrides of phosphorus, arsenic or antimony, having a purity > 99.999%, even diluted in neutral gases.	Optical spectroscopy	Special algorithms are used to control the growth process of the materials.	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22
SUBSTRATE MATERIALS OF DIAMOND, ALUMINA, SILICON AND POLYSILICON	Substrate thickness uniformity < ± 2.5 % across 75 mm	Diamond, Alumina, Silicon and Polysilicon.	Spectroscopic ellipsometer, spectrophotometer. Mechanical lapping and polishing equipment. Electrochemical polishing. Interferometric flatness measurement equipment. Resistance measurement equipment.	Special algorithms are used to control the growth process of the materials.	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22

SECTION 5.3—FABRICATION EQUIPMENT

OVERVIEW

This subsection covers semiconductor processing equipment used to fabricate devices used in military systems (the same process is used in commercial fabrication). Semiconductor processing technology involves the formation of monocrystalline ingots of silicon, sapphire, or gallium compounds which are then sliced into wafers 400–750 microns thick for further processing. This involves the growth of epitaxial layers, implantation of dopants, deposition of thin film layers, delineation of patterns using lithographic techniques, etching, testing, and packaging of integrated circuits (ICs), passive and active devices, and sensors used in military equipment and systems. Microcircuit technology, both hybrid and monolithic, requires sophisticated design and manufacturing equipment technologies to produce integrated, solid-state circuits in which complex electronic functions are obtained using silicon and III/V and II/VI compound semiconductors as the basic material.

Table 5.3-1. Fabrication Equipment Militarily Critical Technology Parameters

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
EPITAXIAL GROWTH EQUIPMENT	Capable of producing a layer thickness uniform to < ± 2.5% across 75 mm	Surface finish, hardness and chemical inertness of metal components; outgassing properties and dimensional stability of system parts	Spectroscopic ellipsometer; spectrophotometer. Equipment for: defect detection and classification; film thickness and uniformity control	Specially designed algorithms for process control	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22
MOLECULAR BEAM EPITAXY EQUIPMENT (MBE)	Capable of producing a layer thickness uniform to < ± 1.5% across 75 mm of III-V or II-VI compound structures; Hall mobility of 200,000 cm^2/ V-se. for GaAs; Defect density < 100 oval defects/cm^2	Surface finish, hardness and chemical inertness of metal components; outgassing properties and dimensional stability of system parts; and solid (effusion cells) and gas sources	Real time closed-loop in situ automated process control; defect detection and classification; film thickness and uniformity control	Specially designed algorithms for process control	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22
METAL ORGANIC CHEMICAL VAPOR DEPOSITION EQUIPMENT (MOCVD)	Capable of producing a layer thickness uniform to < ± 2.5% across 75 mm of III-V or II-VI compound semiconductor structures	Surface finish, hardness and chemical inertness of metal components; outgassing properties and dimensional stability of system parts; and high purity (metal organic gas sources.	Real time closed-loop in situ automated process control; defect detection and classification; film thickness and uniformity control	Specially designed algorithms for process control	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22

(Continued)

Table 5.3-1. Fabrication Equipment Militarily Critical Technology Parameters (Continued)

Technology	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
Ion Implantation Equipment	Accelerating voltage > 200 keV Optimized to operate at an accelerating voltage of < 10 keV. Direct write capability; or High energy implant into a heated substrate.	Surface finish, hardness and chemical inertness of metal components; outgassing properties and dimensional stability of system parts	SEM. (Scanning Electronic Microscope) Equipment for: beam current and energy control; temperature control; defect detection and classification.	Specially designed algorithms for process control	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22
Plasma Dry Etch Equipment with cassette-to-cassette operation and loadlocks	Etch capability of feature sizes < 0.7 microns; Etch profile slope > 60 degrees; Aspect ratio > 3:1; Nitride/Oxide selectivity > 4:1.	Surface finish, hardness and chemical inertness of metal components; outgassing properties and dimensional stability of system parts	SEM (Scanning Electronic Microscope) Equipment for: defect detection and classification; plasma induced damage control; wafer tracking and transport.	Specially designed algorithms for process control	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22
Plasma Dry Etch Equipment/ Cluster Tools	Etch capability of feature sizes < 0.7 microns. Etch profile slope > 60 degrees. Aspect ratio > 3:1. Nitride/Oxide selectivity > 4:1.	Surface finish, hardness and chemical inertness of metal components; outgassing properties and dimensional stability of system parts	SEM (Scanning Electronic Microscope) Equipment for: defect detection and classification; plasma induced damage control; wafer tracking and transport.	Specially designed algorithms for process control	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22
Plasma Enhanced CVD Equipment/ Cluster Tools.	Deposition of tungsten films. Deposition of Boron Phosphide Silicon Glass at > 475 °C. Deposition uniformity better than 3–5% across 150 mm.	High purity source gases	Spectroscopic ellipsometer; spectrophotometer. Equipment for: defect detection and classification;	Specially designed algorithms for process control	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22
Cluster Tools	Integrated automatic loading multi-chamber central wafer handling systems, having interfaces for wafer input/output. With more than two process modules. Single wafer and sequential multiwafer processing.	None identified	Equipment for: defect detection and classification; wafer tracking and transport; communication standardization.	Specially designed algorithms for process control	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22
Lithography Equipment including photo-optical, X-ray, and E-beam.	Light source wavelength < 400 nm or capable of producing a pattern with a resolvable feature size of < 0.7 microns.	Temperature stability, surface finish, optical durability. E-beam/Ion-beam source emissivity.	Equipment for: defect detection and classification; feature size metrology.	Specially designed algorithms for process control	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22

(Continued)

Table 5.3-1. Fabrication Equipment Militarily Critical Technology Parameters (Continued)

Technology	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
E-BEAM MASK AND RETICLE MAKING EQUIPMENT.	Masks capable of producing a pattern with a resolvable feature size of < 1.0 microns. Spot size < 0.2 microns. Overlay accuracy better than ± 0.20 microns (3 sigma).	None identified	SEM; (Scanning Electronic Microscope) Equipment for: defect detection and classification; feature size metrology.	Specially designed algorithms for process control	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22
SEMICONDUCTOR TEST EQUIPMENT	S-parameters of transistors above 31 GHz. Truth testing IC's at a pattern rate > 60 MHz. Testing microwave ICs at frequencies > 3 GHz. Contactless E-beam test systems for operation below 3 keV.	None identified	Equipment for: defect detection and classification; communication standardization.	Specially designed algorithms for process control	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22
PACKAGING AND BONDING EQUIPMENT	Bond pitches < 6 mils. Bonding speed of > 10 wires/sec. Loop heights < 7.5 mils.	Small diameter metallurgically controlled gold/alloy wire, ceramic substrates, sealing compounds, capillary materials, lead frames and ball grid area(BGA) materials.	Equipment for: defect detection and classification; nondestructive testing.	Specially designed algorithms for process control	None
HETERO-EPITAXIAL MATERIALS WITH EPITAXIALLY GROWN LAYERS OF SILICON, GERMANIUM, III/V COMPOUNDS OR II/VI COMPOUNDS	Capability to produce hetero-epitaxial materials consisting of a "substrate" with stacked low defect density epitaxially grown multiple layers of Silicon, Germanium, III/V or II/VI compounds of ± 3 to 5% across 75 mm	Hetero-epitaxial materials with epitaxially grown layers of Silicon, Germanium, III/V compounds or II/VI compounds. Metal-organic compounds and hydrides used as precursors.	MOCVD and MBE epitaxial growth equipment	Specially designed algorithms are used to control the growth process of the materials	WA IL Cat 3 WA ML 11 MTCR 11, 14, 18, 22

SECTION 5.4—GENERAL PURPOSE ELECTRONIC EQUIPMENT

OVERVIEW

This subsection covers general purpose electronic equipment that supports operational military systems. The equipment includes precision time and frequency standards; frequency synthesizers which are derived from precise standards and serve as stable sources for encrypted communication, radar and navigation systems, and various signal analyzers and digitizers that permit collection and analyses of data from enemy weapon systems and information links. Magnetic recording equipment permits permanent records of the collected data.

Table 5.4-1. General Purpose Electronic Equipment Militarily Critical Technology Parameters

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
DIGITIZER, WAVEFORM	Digitizing rate of 200 million samples/sec. and a resolution of 10 bits or more, and a continuous throughput of 2 Gbit/sec or more	None identified	None identified. Commercially produced equipment.	None identified	WA IL Cat 3
STANDARD, FREQUENCY, ATOMIC	Long term stability >1 x 10^{-11}/month	None identified	None identified Equipment is produced commercially	None identified	WA IL Cat 3
RECORDERS, DIGITAL INSTRUMENTATION MAGNETIC TAPE	Transfer rate > 175 Mbit/s.	None identified	None identified	None identified	WA IL Cat 3
RECORDERS, DIGITAL CONVERSION EQUIPMENT	Transfer rate > 175 Mbit/s.	None identified	None identified	None identified	WA IL Cat 3
FREQUENCY SYNTHESIZERS-ASSEMBLIES	Switching time < 1 ms., or SSB phase noise better than (126 + 20 $\log_{10}F$ -20 $\log_{10}f$) in dBc/Hz (F is offset from operating frequency in Hz, and f is the operating frequency in MHz)	None identified	None identified	None identified	WA IL Cat 3
FREQUENCY SYNTHESIZERS-SIGNAL GENERATOR	Operating frequency > 1 GHz and switching time < 1 ms., or SSB phase noise better than -(126 + 20 $\log_{10}F$ - 20 $\log_{10}f$) in dBc/Hz (F is offset from operating frequency in Hz; f is the operating frequency in MHz)	None identified	None identified	None identified	WA IL Cat 3
ANALYZER, SIGNAL, SCANNING	Operating frequency > 1 GHz	None identified	None identified	None identified	WA IL Cat 3
ANALYZER, DYNAMIC	Real time bandwidth > 25.6 kHz	None identified	None identified	None identified	WA IL Cat 3

SECTION 5.5—MICROELECTRONICS

OVERVIEW

This section covers microcircuits [including General Purpose Integrated Circuits (IC)], hybrid microcircuits, and MMIC (millimeter/microwave IC), which are a subset of microcircuits and includes hybrid MMIC and monolithic MMIC operating at frequencies greater than 30 GHz. Also covered are integrated circuit design and evaluation testing involving Computer Aided Design (CAD) of integrated circuit packages. Electronic packaging technologies are required to achieve the inherent high speed, high power, and severe environment of the basic building block microcircuits.

Table 5.5-1. Microelectronics Militarily Critical Technology Parameters

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
RAD-HARD INTEGRATED CIRCUITS	$\geq 5 \times 10^6$ Rads(Si) Total dose or $\geq 5 \times 10^8$ Rads(Si)/sec dose rate	Wafer flatness, min. defects and uniformity for advanced ICs	Dielectric Isolation, deep implant on SOS and SOI, controlled doping, surface passivation and controlled radiation testing	Computer modeling software. Pre and post radiation modeling. SEU (Single Event Upset) models.	WA IL Cat 3
TEMPERATURE-RATED INTEGRATED CIRCUITS	Capability of operation at either temperature extreme or over the specified temperature range of –55 °C to + 125 °C.	Ceramic substrates	None identified	Thermal analysis models	WA IL Cat 3
GENERAL PURPOSE MICROPROCESSORS	ALU ≥ 32 Bits CTP ≥ 80 MTOPS Frequency ≥ 80 MHz	Wafer flatness, min. defects and uniformity for advanced ICs	Lithography, Epitaxy, Deposition masks and resists for High Density chips High Speed Testing equipment	HDL (High-Level Development Language) CAE and ATE	WA IL Cat 3
DIGITAL SIGNAL PROCESSORS (DSP)	1024 point complex FFT ≤ 1 msec 100 mFLOPS Data bus ≥ 16 bits	Wafer flatness, min. defects and uniformity for advanced ICs	Lithography, Epitaxy, Deposition masks and resists for High Density chips High Speed Testing equipment	Simulation and modeling HDL (High-Level Development Language) CAE and ATE	WA IL Cat 3
ARTIFICIAL NEURAL NETWORK (ANN) ICS	400,000 pixels/chip for graphics, 100,000 connections per sec.	Wafer flatness, min. defects and uniformity for advanced ICs	Lithography, Epitaxy, Deposition masks and resists for High Density chips High Speed Testing equipment	Training algorithms Simulation algorithms Simulation and modeling HDL (High-Level Development Language) CAE and ATE	WA IL Cat 3

(Continued)

Table 5.5-1. Microelectronics Militarily Critical Technology Parameters (Continued)

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
A/D CONVERTER	8 to 12 bits - 10 nanosec 12 bits - 2 microsec ≥ 12 bits - 5 microsec	Wafer flatness, min. defects and uniformity for advanced ICs	Lithography, Epitaxy, Deposition masks and resists for High Density chips High Speed Testing equipment	Simulation and modeling HDL (High-Level Development Language) CAE and ATE	WA IL Cat 3
D/A CONVERTER	≥ 12 bits - ≤ 100 ns	Wafer flatness, min. defects and uniformity for advanced ICs	Lithography, Epitaxy, Deposition masks and resists for High Density chips High Speed Testing equipment	Simulation and modeling HDL (High-Level Development Language) CAE and ATE	WA IL Cat 3
GALLIUM ARSENIDE ICS	≥ 5000 equivalent (2 input) gates ≥ 1 GHz toggle frequency	GaAs Epitaxial Wafers Wafer flatness, min. defects and uniformity for advanced ICs	Lithography, Epitaxy, Deposition masks and resists for High Density chips High Speed Testing equipment Chip probing Modified for GaAs - including MBE	Simulation and modeling HDL (High-Level Development Language) CAE and ATE	WA IL Cat 3
FIELD PROGRAMMABLE DEVICES	25,000 usable gates (realizable) 133 MHz	Wafer flatness, min. defects and uniformity for advanced ICs	Lithography, Epitaxy, Deposition masks and resists for High Density chips High Speed Testing equipment	Standard Cell S.W. Simulation and modeling HDL (High-Level Development Language) CAE and ATE	WA IL Cat 3
ASICS (CUSTOM INTEGRATED CIRCUITS)	0.35 ns gate delay 180 pins	Wafer flatness, min. defects and uniformity for advanced ICs	Lithography, Epitaxy, Deposition masks and resists for High Density chips High Speed Testing equipment Chip probing	Standard Cell S.W. Simulation and modeling HDL (High-Level Development Language) CAE and ATE	WA IL Cat 3
MEMORY ICS; - SRAMS; - COMPOUND SEMICONDUCTOR MEMORIES	Memory capacity and maximum access time. SRAM ≥ 4 mbits ≤ 10 ns	Wafer flatness, min. defects and uniformity for advanced ICs	Lithography, Epitaxy, Deposition masks and resists for High Density chips High Speed Testing equipment	Standard Cell S.W. Simulation and modeling HDL (High-Level Development Language) CAE and ATE	WA IL Cat 3
COMPOUND SEMICONDUCTOR ICS	≥ 1300 equivalent (2 input) gates ≥ 1.2 GHz toggle frequency	Compound materials (semiconductor, e.g. III/V and II/VI)	Lithography, Epitaxy, Deposition masks and resists for High Density chips High Speed Testing equipment Chip probing Modified for compound materials	CAE and ATE	WA IL Cat 3

(Continued)

Table 5.5-1. Microelectronics Militarily Critical Technology Parameters (Continued)

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
MULTICHIP MODULES (MCMS)	270 watts/meter/ °K heat dissipation Dielectric constant of K = 5.4 hermeticity, etc.	Matched substrate material thermoconductivity, heat transfer and strength	None identified	MCM board station software CAE and ATE	WA IL Cat 3
DIAMOND SUBSTRATES FOR IC PACKAGES	Heat dissipation 700–1500 watts/meter/ °K	Diamond films Diamond substrates	CVD process	None identified	WA IL Cat 3
DIGITAL GATE ARRAYS (SILICON)	≥ 150,000 equivalent (2 input) gates ≥ 100 MHz toggle rate	Matched thermoconductivity, heat transfer and strength	Lithography, Epitaxy, Deposition masks and resists for High Density chips High Speed Testing equipment	HDL (High-Level Development Language) Standard Cell S.W. CAE and ATE	WA IL Cat 3

SECTION 5.6—OPTO-ELECTRONICS

OVERVIEW

This section focuses on Opto-Electronics (OE) (which includes electro-optics and optronics) devices, components, and systems that are used in signal processing, image processing, or computing, and the switching, interconnection, and related devices associated with these functions. What distinguishes these from other signal and image processors is that they utilize photons as the information carrying form of energy. The OE devices covered in this section can be broadly broken into two categories: analog and digital. By and large, the only technologies that have developed sufficiently to be considered militarily critical are of the analog type. Real-time analog optical processing is employed in correlators, spectrum analyzers, and in some target recognition devices by the military. Digital optical processing is still in the emerging state and, although there are many instances of its use in military systems, it will be some time before it reaches its potential. While there are important military applications of OE technologies, most of the underlying technology and device development is being driven by high-volume commercial applications. In fact, many important military applications are depending upon commercial market forces to develop the underlying technology and devices sufficiently to meet future military needs.

Table 5.6-1. Opto-Electronics Militarily Critical Technology Parameters

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
SIGNAL PROCESSORS, ACOUSTO-OPTIC BRAGG CELLS	Bandwidth > 1 GHz Dynamic range > 60 dB Time bandwidth > 1000	Gallium phosphide	Growing gallium phosphide boules	None identified	WA IL Cat 3
SIGNAL PROCESSORS, ACOUSTO-OPTIC 1-D DETECTOR ARRAYS	Bandwidth > 1 GHz > 1024 elements Readout < 10 microseconds	None identified	None identified	None identified	WA IL Cat 3
SIGNAL PROCESSORS, ACOUSTO-OPTIC 2-D DETECTOR ARRAYS	1024 ×1024 minimum array 300 frames/sec minimum 40 dB dynamic range minimum	None identified	None identified	None identified	WA IL Cat 3
PHASED ARRAYS, OPTICAL CONTROL-BEAMFORMING TECHNIQUES	Bandwidth > 10% for L band and X-band operation.	Indium phosphide and related III-V semiconductor alloys	None identified	None identified	WA IL Cat 3
FIBEROPTIC LINES, HIGH-SPEED ANALOG	Bandwidth > 15 GHz Dynamic Range > 120 dB/Hz Noise figure (< 5 dB)	Indium phosphide and related III-V semiconductor alloys	None identified	None identified	WA IL Cat 3
FIBEROPTIC LINKS, HIGH-SPEED ANALOG-DIRECTLY MODULATED LASER DIODES	RIN (Relative Intensity Noise) (< –140 dB/Hz) Modulation rate > 15 GHz	Indium phosphide and related III-V semiconductor alloys	None identified	None identified	WA IL Cat 3

(Continued)

Table 5.6-1. Opto-Electronics Militarily Critical Technology Parameters (Continued)

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
FIBEROPTIC LINKS, HIGH-SPEED ANALOG MICROCHIP SOLID-STATE LASERS	Power > 150 mW into single-mode fiber	Indium phosphide and related III-V semiconductor alloys	None identified	None identified	WA IL Cat 3
FIBEROPTIC LINKS, HIGH-SPEED ANALOG WAVEGUIDE MODULATORS	Power handling > 150 mW Modulation rate > 15 GHz	Lithium niobate, lithium tantalate	None identified	None identified	WA IL Cat 3
FIBEROPTIC LINKS, HIGH-SPEED ANALOG HIGH-SPEED DETECTORS	Power handling > 150 mW Frequency response > 94 GHz	Low-temperature gallium arsenide, low temperature indium-gallium-arsenide	None identified	None identified	WA IL Cat 3